TELEPHONE SYSTEM DESIGN - SIZING CRITERIA

CONTENTS

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, and other interested parties with technical information to be used as a basis for the design of REA borrowers' systems. It discusses, in particular, sizing of facilities.

1.2 The purpose of this revision is to modify the plant selection criteria to recognize the virtual elimination of eight-party service in new designs and the accelerating movement to one-party service in rural areas of REA borrowers. Another purpose is to emphasize that electronic devices (carrier and remote switching units) are full fledged alternatives to cable pairs. We anticipate the new criteria will accelerate movement toward REA borrowers' long range goal of a one-party line in every rural home.

1.3 More emphasis is placed on the establishment (rather than subscriber) density, rates of growth, initial grades of service, and types of service as criteria. Table I is a departure from earlier issues which established criteria based on what was considered the average situation of all REA borrowers.

1.4 Various objectives of the telephone system need to be considered and essential long range (10 year) objectives established. On the average, REA borrowers' investment in plant is doubling at 7-year intervals as is the entire telephone industry. Major reinforcements are taking place at 4- to 8-year intervals.

1.5 For most systems, long range planning will encompass upgrading to one-party service and the introduction of new types of communication services over the next 10 years. It is intended that the construction to be undertaken initially will be flexible enough to permit meeting future service requirements with a minimum disruption in the operation of the system. Additional considerations may be retirement of high maintenance or obsolete plant facilities; new wire center predictions; and elimination of small CDO's, joint use, or other aerial plant.

1.6 Table I "General Guide for the Provision of Components of Telephone Plant" has been revised to emphasize that the quantities of some items (A.2) in the plans and specifications will be less than in the 5-year design.

1.7 Borrowers should generally plan sufficient construction funds in telephone system loan budgets to finance the estimated communications requirements of the community for a 5-year period. Funds are also required for additional capacity beyond the fifth year in those components of telephone plant which are not economically expansible in 5-year increments. See Table I (B.).

1.8 This revision conforms this section to the 1971 issues of TE & CM Sections 203, 204, 205; REA Bulletin 320-14, "Loans for Telephone Systems Improvements and Extensions"; and REA Bulletin 322-1 (TE & CM 206), "Area Coverage Survey."

2. CRITERIA FOR OUTSIDE PLANT SIZING

2.1 The estimated 5-year subscriber requirements (REA Form 569), the system's previous 10 years' growth and predictions of future growth discussed in the system's Area Coverage Survey will influence the design. The criteria in Table II presume an area of steady economic and/or telecommunications growth. In areas of no growth in telecommunication requirements a more conservative approach such as the circuit-by-circuit design method (Paragraph 5) can be used.

2.2 There is a greater need for flexibility of plant facilities on routes with densities of more than 15 establishments per mile than in most rural areas.

2.21 Service requirements are more unpredictable in such areas. There is likely to be more station movement involving installations, changing grades of service, and temporary idle services and disconnects.

2.22 The proportion of one-party lines and multiline requirements is much greater in such areas. There may be demand for push button dial, key systems, PABX's, data sets, facsimile, mobile radio, paging, educational TV, and other more sophisticated services.

2.3 In rapidly growing suburban or semirural areas it is generally practical to provide cable pairs in excess of initial requirements since the cost per subscriber of outside plant is substantially less than in more rural areas. However, when (1) at least 70 percent of the 5-year subscribers are not already taking service and (2) there is a high proportion of "future" establishments (especially in speculative land developments), a more conservative approach should be taken to avoid providing the existing subscribers with plant that might not be put into service for 5, 10, or more years.

2.4 The outside plant design recommendations for new cables recognize that reinforcement of large cables is more practical and (on a per pair basis) less costly than reinforcing small size facilities. In the extreme, a new 25 pair 24 gauge cable (including housings, loadings, etc.) one mile extension at $2,100 per mile costs no more than a 2-22 buried wire ($1,100) followed in later years with a small reinforcing cable or with as few as three channels of carrier ($1,200 or more). Note, however, there is little increase in cost in a 200-pair cable and a 100-pair reinforcement rather than a single 300-pair cable initially. For 200 pair and more, the cost per pair remains fairly constant. Therefore, the time interval before reaching capacity of small size cables should be greater than for large size cables. See TE & CM 218, "Plant Annual Costs," for considerations other than initial cost.

2.5 To encourage maximum telecommunications development of an area, more liberal sizing of new cables under 100 pair is being recommended. Minimum cable sizes in Table II are based on 5 year subscribers not 5 year circuit requirements. Note, however, that the use of electronic equipment for feeder circuits may be more economical than full size cables, especially when existing cable pairs may be used. New 24 gauge cable can be used extensively. Carrier is assumed initially on new 19 and 22 gauge cables of 6 pair or more.

2.6 For increased flexibility in outside plant, it is recommended that in loaded complements for cables of 50 pair or less the slate colored cable pair (pair numbers 5, 10, 15.....50) be (1) reserved as a spare, (2) left without load coils, and (3) to the maximum practical extent made continuous to the main distributing frame. This pair will then be available for reinforcement by station carrier. With one non-loaded spare pair in each group (blue, orange, green, brown, slate) of five, it is possible to double the cable capacity with a station carrier system with as few as four channels per pair. In larger cables it will generally be practical to group the non-loaded pairs in the same 25 pair binder group.

2.7 PCM trunk and subscriber carrier may require pair selection unless compartmentalized cable (carrier screen) is provided.

2.8 In Table II the minimum number of spare pairs over and above those required to meet the 5-year subscriber requirements of the area coverage survey account for a minimum of 20 percent of the pairs in cables 25-pair and above. The minimum percent of spares (over 5-year requirements) in 12- and 18-pair cables is 17 percent and in 6-pair cables it is 33 percent.

3. SELECTION OF PLANT COMPONENTS

3.1 Table I is a general guide for the provision of plant components. Part (A1) lists the major components of plant which are generally provided on the basis of the 5-year estimate of requirements. Part (A2) lists plant items that may often be economical to reinforce at intervals of less than 2 or 3 years. Part (B1) lists plant components that should generally provide capacity for a longer period than 5 years because incremental reinforcement at 5-year intervals is almost invariably impractical and/or uneconomical.

3.2 TE & CM 203, "Existing Plant Considerations for a Telephone System Design", TE & CM 204, "Telephone System Design"; give further guidance in providing new facilities for rural areas.

3.3 Outside Plant

3.31 Sizing of cable and electronic plant will generally follow the recommendations in paragraph 2 and Table II of this section, but some systems may require the less flexible but lower first cost system described in paragraph 5, Circuit-by-Circuit Design.

3.32 Conduit Systems and Manholes - New and expanded conduit systems must be given special attention, and each application should be given individual study by the engineer. While it has been customary to think in terms of 25- to 50-year life, this does not mean that 8 ducts, each of which is large enough to hold a 3,600-pair cable or a 21 tube coaxial cable, should be provided because eight 150-pair cables are anticipated 25 or more years from the installation date. At the other extreme, if conduit is really required, the incremental cost of a 4-duct system over a 2-duct system is minor compared to the overall cost of the underground system. Within this framework it is recommended that for new conduit systems there should be about as many idle ducts initially as there are occupied ducts. Do not overlook oversize cables as an alternative to a conduit system. If a conduit system can be deferred for 5 years, it should be deferred. Paving schedules may control.

3.4 Central Office Equipment

3.41 Switching Equipment -- The criteria for central office sizing is covered in REA TE & CM Section 325, "Application Guide for the Preparation of Detail Dial Central Office Equipment Requirements" and REA TE & CM Section 335, "Application Guide for the Preparation of Detailed Common Control Central Office Equipment Requirements. Generally central office equipped lines in the SLP (or ACD) and

later in the plans and specifications are to be estimated based on the 5-year subscriber needs. Common control equipment (Large and Small Ultimate Size) and other new common equipment such as senders and ANI as well as battery, charger, and standby engine generator are sized on a long range basis according to their estimated service life in one location or in other locations.

3.42 Trunking -- Interoffice trunk requirements may be estimated for several time periods in the SLP (or ACD). Trunks to a connecting company may vary in makeup depending on the ownership arrangements. The initial installation of transmission facilities and switching equipment should be adequate for a reasonable period after cutover. In small to medium size central offices (1,000 lines or less) the 5-year estimate of the number of central office trunks should generally be installed initially even when the connecting company intends to furnish less than this number. The extra trunk circuits are available for standby service if the in service units have to be turned down. In larger offices 2- or 3-year increments may be desirable.

3.43 Carrier and Radio -- Station and trunk carrier and radio multiplex equipment plans and specifications quantities may be based on a shorter period than 5 years. There should be a definite long range plan to provide sufficient outside plant and electronic equipment housing capability for easy expansion with electronic equipment. Additional channel ends, and in large offices, additional systems can be delivered and installed at relatively short intervals on a well designed system. For trunks to a connecting company where each company owns the carrier terminals in its office, the number of channels to be installed initially should not exceed the 5-year estimate. The initial installation of intrasystem trunk carrier should be a logical increment, keeping in mind the need to be able to add or transfer equipment as actual traffic dictates. Station carrier should be based on initial requirements, including spare capacity, with future additions planned as more circuits are needed.

3.44 Mobile Telephone Equipment (Base Station) -- This equipment generally contains the transmitter and receiver for one mobile telephone channel which can handle the traffic generated by about 20 subscribers. An additional transmitter and receiver and associated control terminal equipment are required for each additional channel. The automatic channel hunting feature of IMTS provides an increase in traffic per channel as channels are added. Although most systems begin with only one channel, expansion capability should be planned for at the outset. Paging can be accommodated on a mobile radio channel without disruption of the mobile service.

3.45 Microwave Radio Equipment -- For large trunk groups or in mountainous or other types of difficult terrain, microwave may offer flexibility, reliability and economy. In a well designed system, towers, antennas, and RF equipment are based on a long range projection so that multiplex channels can be added biannually (or even annually) without modifications of the basic baseband arrangement.

3.5 Station Equipment

3.51 In the past, station equipment has been a component of plant that normally was based directly on the total number of subscribers at conversion to dial and at the end of the 5-year period. Station equipment requirements are much more difficult to estimate now.

3.52 In addition to realistic estimates of the type of equipment the subscribers will be using initially and at the end of 5 years, judgment is required to anticipate the penetration of subscriber owned equipment.

3.53 The percentage of subscriber owned equipment may depend on the lead time required by the telephone system to provide the more complicated subscriber equipment such as PABX, Facsimile, Key Systems, ETV, Data Modems, etc.

3.54 Plans and specifications should include sufficient station equipment for initial requirements plus a margin for spares. Buried services should contain two pairs minimum. Subscribers with two or more lines initially should have a 6 pair or larger buried service. New station wiring should preferably have jack outlets in one or more rooms. Plug ended extensions should be provided at premises equipped with jacks.

3.6 Buildings

3.61 CDO Buildings -- Considerable care should be used in determining the size of buildings, as it is usually more costly (on a first cost and an annual charge basis) to enlarge small structures if more space is needed in the future. Unattended dial central office buildings are intended to have a service life of approximately 25 years, and should be designed for long range requirements reasonably expected during that time. There should be adequate space for the total number of lines of switching equipment for trunk and subscriber needs. Space for carrier, radio, automatic toll ticketing, cable vaults or other special items (such as dehumidifiers, dust precipitators, air conditioners, test equipment, toilets, desks, benches, file cabinets, tables, etc.) should be taken into consideration. In areas with temperature extremes the significant annual cost of heating and cooling a larger building should not be ignored.

3.62 Land and Headquarters Buildings -- Plans should include long term acquisition of land and a plan for possible building expansion in an orderly fashion. Comparative costs to put in a semi-permanent or curtain wall to facilitate horizontal expansion to a larger building at a later time should be investigated. Alternative vertical expansion should also be considered. Commercial office buildings or combination central office and commercial office buildings should be given extensive study by the engineer and an architect, giving full consideration to the long range plans and needs of the borrower.

4. EFFECT OF SUBSCRIBER SURVEY REVISIONS ON PLANS AND SPECIFICATION

4.1 Prestaking Subscriber Survey -- When complete ACS maps have not been prepared in the preloan stage, it will be necessary to do so prior to staking. In any event it is desirable to survey (in person or by mail) unserved establishments for further subscriber sign up so that the forecast can be confirmed or updated, existing maps can be updated, or new maps can be prepared.

4.2 At the time plans and specifications are to be prepared, establishments rated as potentials for a particular type of service in the preloan period may have become signed subscribers. "Future" establishments may no longer be bona fide potentials. Thus it is to be expected that subscriber information will be changing as the project progresses through its various stages. The proportion of existing subscribers and held orders to the total establishments will fluctuate. Between the loan proposal (SLP or ACD) and plans and specifications stage, continued activity will result in more accurate information on the immediate demand for telephone service in the area. This fact, in conjunction with the shorter engineering periods applying to the plans and specifications stage for some components of plant (central office lines, carrier, station installations, etc.) indicates that more precise initial estimates can be made in the plans and specifications than in the preloan planning stage.

5. ALTERNATIVE OUTSIDE PLANT CRITERIA, CIRCUIT-BY-CIRCUIT DESIGN

5.1 The circuit-by-circuit design method described below (station carrier is used in lieu of cable pairs when economical) is no longer recommended but may still have application in exchanges where a feasible four-party design cannot be developed using the 1974 recommendations of paragraph 2.

5.2 To use the circuit-by-circuit method of design, existing subscribers and 5-year potential subscribers are assigned to loops taking into consideration (1) class of service, (2) inductive loading points, (3) bridge taps, (4) outer end section limitation, (5) station or PCM subscriber carrier, (6) remote electronic switching units, (7) plant flexibility, and (9) spare cable pairs for maintenance and unanticipated demand.

5.3 The circuit-by-circuit design procedure uses the existing and future establishment distribution shown on the detail maps developed as part of the Area Coverage Survey and existing and potential subscriber sign-up information. It converts subscriber data (location and grade of service) into subscriber loop requirements and facilitates low initial cost loop design through maximum utilization and assignment of the circuits provided. It provides little flexibility for subscriber growth and upgrading, not anticipated within 5 years of the preparation of the ACS.

5.4 The number of subscriber circuits is determined by using the designated number of subscribers per line based on the class of service, with at least 10% spare circuits being provided in addition.

TABLE I

GENERAL GUIDE FOR THE PROVISION
OF COMPONENTS OF TELEPHONE PLANT

A. Plant Components to be Provided to Reach Capacity in Approximately 5 Years

1. Approximately Same Quantities in SLP (or ACD and Plans and Specifications)

Outside Plant:
- Buried, Aerial, and Underground Cable - Large Size
- Above Ground Load Coils
- Buried Load Coils (Easy to reinforce)

Central Office Equipment:
- Switching Equipment, Interoffice Trunks
- Common Usage Equipment (ANI, CMO, Pushbutton Dialing, Call Waiting, Abbreviated Dialing, Conference Calling, etc.)
- Voice Frequency Repeaters,
- Loop Extenders, etc.

2. Plant Components Frequently Having Reduced Quantities in Plans and Specifications From Those Shown in SLP (or ACD)

Outside Plant:
- Ready Access Enclosures
- Other Facilities for "Futures" and "Potentials"

Central Office Equipment:
- Radio Multiplex, Trunk and Subscriber Carrier (including carrier repeaters)

Station Equipment:
- Telephone Sets, Inside Wiring, Protectors, Drops or Services, Facsimile, Data Sets, Key Systems, Mobile Radio Units, PABX, etc.

B. Plant Components to be Provided Which Do Not Reach Capacity in 5 Years

1. Approximately Same Quantities in SLP (or ACD) and Plans and Specifications

Outside Plant:
- Pole Line (Poles, Strand, Guys, Anchors, Passive RF Repeaters, Antennas, Towers, etc.)
- Conduit and Manholes
- Buried Plant Housings
- Buried and Aerial Wire
- Carrier Repeater and Station Carrier Housings
- Buried, Aerial, and Underground Cable - Small Size
- Buried Load Coils (Difficult to Reinforce)

Central Office Equipment:
- Batteries, Chargers, Engine Generators, Ringing Generators
- Microwave Transmitters and Receivers,
- Mobile Radio Base Station Equipment,
- Estimate of "ultimate" Switchboard Size

Station Equipment:
- Buried Services, Inside Wiring,
- Channel Capacity of Mobile Units

Land and Buildings:
- CDO, Headquarters, Warehouse, Garage, and Microwave

TABLE II

Outside Plant Facility Size Selection
(For Areas With Growing Telecommunication Requirements)

Five-Year * Subscriber Estimate	Minimum Recommended Size for Single Physical Facility	Minimum Recommended Cable Size When Some Circuits are Derived by Carrier ##
1	2-22	2
2	6-24, 2-22, or 2-19 **	2
3-4	6-24, 22, or 19	2
5-10	12-24, 22 or 19	6
11-15	18-24, 22 or 19	6
16-20	25-24, 22 or 19	12
21-30	50-24, 37-22 or 19	12
31-40	50-24, 22, or 19	25
41-60	75-24, 22, or 19 ***	25
61-80	100-24, 22, or 19 ***	25
81 or More	Select size so as not to exceed 80 percent fill within 5 years. ###	Select Cable so that it is not more than 50 percent saturated in 5 years, with the carrier system selected.

* It is recommended that 5-year circuit requirements not be the criteria for cable sizing. See paragraph 2.5 for discussion. Where feasibility is a problem, the concept of eventual one-party service in every rural home may be achieved by assuming carrier expansion beyond the fifth year.

** In new construction, 19 gauge (50-mile physical capability) is generally not economical for physical circuits since it is not required less than 20 to 25 miles from the central office. Twenty-two gauge (25-mile physical capability) is generally not economical for physical circuits, since it is not required less than 10 miles from the central office. In severe lightning areas, 26 gauge cable in less than 100-pair size is not recommended.

*** For 41 circuit requirements and more, carrier plus a smaller 19 gauge or 22 gauge cable (or dual fine and coarse gauge cables) generally are more economical than a single coarse gauge cable.

Permits an eventual two circuits per 5-year subscriber with 6 channel carrier systems on all pairs. When good existing plant can be used economically as a carrier vehicle and no new paralleling cable is necessary, these minimum cable sizes should not control.

Use 80 percent fill unless reinforcements will be considerably more costly than the initial installation. In such cases lower 5-year fills may be justified. Oversize cable as an alternative to conduit is such an example.

In new construction, it is recommended that the slate pair (1) be retained as a spare, (2) not be loaded, and (3) be made continuous to the main distributing frame. It is then available for carrier reinforcement. Even with as few as four-carrier channels per pair, circuit capacity of loaded cables can be doubled as a result.

Do not overlook existing and future trunk circuit requirements including spare span lines and interrogation circuits when sizing cables.